(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 February 2002 (28.02.2002)

PCT

(10) International Publication Number
WO 02/16907 A1

(51) International Patent Classification[7]: G01N 3/46, 19/02

(21) International Application Number: PCT/GB01/03823

(22) International Filing Date: 22 August 2001 (22.08.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0020808.2 23 August 2000 (23.08.2000) GB

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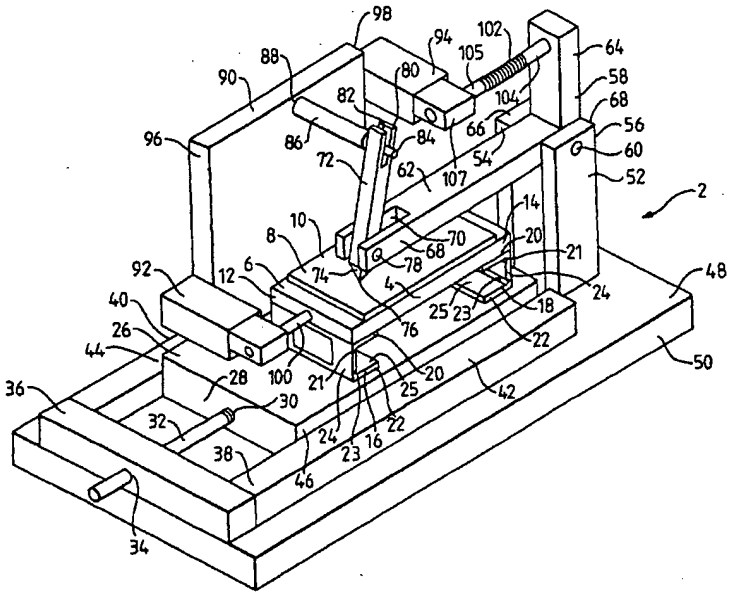
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

[Continued on next page]

(54) Title: SCRATCH RESISTANCE TESTING APPARATUS AND METHOD



(57) Abstract: A testing apparatus for evaluating the scratch resistance of a sample, apparatus comprising a support for the sample to be tested, a holder for a scratching tool, a drive device for causing relative translational movement between the support and the holder and an inclination varying device for progressively varying an angle of incidence between the scratching tool and a sample surface during relative translational movement between the scratching tool and the sample surface.

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SCRATCH RESISTANCE TESTING APPARATUS AND METHOD

The present invention relates to a testing apparatus for evaluating the scratch resistance of a sample and to a method of evaluating the scratch resistance of a sample.

For a variety of different engineering applications it is necessary or desirable to quantify the resistance of a surface of an article to damage by scratching. A number of known methods and associated instruments exist for evaluating the scratch resistance of surfaces, including the surfaces of both metallic and non-metallic materials which may be uncoated or coated by soft or hard coatings. All such known methods and instruments involve the drawing of a scratching tool or indenter across the surface of the material to be tested under conditions of uniform or increasing load. The tool or indenter has a sharp pointed tip which engages the sample surface. The tool or indenter is maintained at a constant angle of incidence to the surface.

These known methods and instruments suffer from some technical disadvantages. The severity of the scratch resistance test depends on the condition of the pointed tip of the tool or indenter. If the pointed tip is worn, then the scratch resistance test is less severe. Accordingly, the known scratch resistance methods can exhibit poor repeatability. Second, the useful lifetime of the tool or indenter can be relatively low as a result of rapid wear of the pointed tip.

The present invention aims at least partially to overcome these problems by providing a scratch resistance testing

apparatus and method which enables a higher testing repeatability and increased lifetime of the tool or indenter to be achieved.

The present invention accordingly provides a testing apparatus for evaluating the scratch resistance of a sample, the apparatus comprising a support for the sample to be tested, a holder for a scratching tool, a drive device for causing relative translational movement between the support and the holder and an inclination varying device for progressively varying an angle of incidence between the scratching tool and a sample surface during relative translational movement between the scratching tool and the sample surface.

The present invention further provides a method for evaluating the scratch resistance of a sample, the method comprising supporting a sample to be tested on a support, disposing a scratching tool having a pointed end in a holder whereby the pointed end engages a surface of the sample to be tested, causing relative translational movement between the support and the holder whereby the pointed end is translated relative to the sample surface, and progressively varying an angle of incidence between the scratching tool and the sample surface during relative translational movement between the scratching tool and the sample surface.

The present invention is predicated on the discovery by the present inventor that by varying the angle of incidence of the scratching tool or indenter relative to the surface of a sample to be tested, the testing method can more accurately simulate potential scratching conditions which a sample surface is likely to experience in use wherein the magnitude and severity of a scratch are not only dependent on the force

of application and the shape of the scratching device, but also on the angle of incidence of the scratching device relative to the surface. By varying the angle of incidence of the scratching tool or indenter relative to the surface to be tested, this enhances not only the repeatability of the scratching test, but also tends to increase the life of the scratching tool or indenter. It is believed that by varying the angle of incidence of the scratching tool or indenter relative to the surface to be tested, localised changes in the angle of incidence are masked, thereby increasing the repeatability of the test, and correspondingly the lifetime of the tool for achieving the required repeatability. The load between the scratching tool or indenter and the sample surface can be maintained constant or varied, preferably so as to increase the load with corresponding variation of the angle of incidence between the scratching tool or indenter and the surface to be tested.

An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

Figure 1 is a schematic perspective view of a testing apparatus for evaluating the scratch resistance of a sample in accordance with an embodiment of the present invention.

Referring to Figure 1, there is shown an apparatus, designated generally as 2, for evaluating the scratch resistance of a sample in accordance with an embodiment of the invention. The apparatus 2 includes a platen 4, which in the illustrated embodiment is rectangular in plan, having an upper surface 6 on which, in use, a sample 8 to be tested is horizontally supported. The sample 8 is firmly affixed to the platen 4 by

a fixing device (not shown). When so supported, the sample 8 presents an upper surface 10 to be tested for scratch resistance. The platen 4 is supported at its opposed ends 12,14 by respective flexures 16,18. Each flexure 16,18 extends across the transverse width of the respective end 12,14 of the platen 4. Each flexure 16,18 is substantially C-shaped in cross section and includes upper and lower horizontal wall members 20,22 connected by a vertical wall member 24. The platen 4 is affixed to the upper horizontal wall members 20 and the lower horizontal wall members 22 are affixed to a linear slide body 26. A pair of elongate upper and lower notches 21,23 are provided in the inner surface 25 of the flexures 16,18 at the junctions between the respective upper and lower wall members 20,22 and the vertical wall member 24.

The linear side body 26 is substantially rectangular in plan and at one end 28 thereof is engaged by one end 30 of an elongate threaded lead screw 32. The lead screw 32 is horizontally oriented and extends through a correspondingly threaded hole 34 in an end base member 36 of a linear slide base 38. The lead screw 32 is adapted to be rotated either manually or by an electric motor (not shown) so as translationally and horizontally to displace the linear slide body 26 relative to the end base member 36. The linear slide base 38 further comprises a pair of parallel slide members 40,42 which extend orthogonally away from the end base member 36 and slidably engage the respective opposed longitudinal sides 44,46 of the linear slide body 26. The linear slide base 38 is secured to the upper surface 48 of a base plate 50. In use, the linear slide body 26 slides along the upper surface 48 of the base plate 50 by selective rotation of the lead screw 32.

A vertically oriented bracket 52 is mounted on the base plate 50. The bracket 52 comprises a pair of parallel spaced bracket members 54,56. An L-shaped arm 58 is rotatably mounted between the bracket members 54,56 by a pivot bearing 60. The L-shaped arm 58 comprises a generally horizontally oriented support member 62 extending above the platen 4 and a generally vertically oriented urging member 64 which extends upwardly from the pivot bearing 60. The pivot bearing 60 extends horizontally between the upper ends 66,68 of the bracket members 54,56 and through the L-shaped arm 58 at the junction between the support member 62 and the urging member 64.

The support member 62 is provided at the free end 68 thereof with an elongate slot 70 for receiving a substantially upright-oriented holder 72 for holding a scratching tool, or indenter, 74. The scratching tool 74 has a pointed tip 76 which, in use, engages the upper surface 10 of the sample 8 to be tested. The holder 72 is pivotally mounted on the free end 68 of the support member 62 by a pivot bearing 78. Accordingly, in use, the angle of incidence between the pointed tip 76 of the tool 74 and the sample surface 10 can be varied by rotating the holder 72 about the pivot bearing 78. The free upper end 80 of the holder 72 is provided with a downward directed slot 82, which may be a slotted hole or notched fork, in which is removably located one end 84 of a pin member 86. The pin member 86 is substantially horizontally oriented and the other end 88 thereof is affixed to a support wall 90 which is fixed to and extends upwardly away from the linear slide body 26. The first and second force transducers 92,94 are respectively attached to the opposed upright edges 96,98 of the support wall 90. The first

force transducer 92 is connected by a rod 100 to the end 12 of the platen 4 which faces toward the lead screw 32. The second force transducer 94 is connected to the urging member 64 by means of a biasing device comprising a helical tension spring 102, a screw threaded adjuster rod 104 threadably mounted on the urging member 64, and a second adjuster rod 105 which is threadably mounted on an extension 107 of the second force transducer 94.

The operation of the testing apparatus 2 will now be described.

In use, the sample 8 to be tested is fixedly mounted on the platen 4 and a scratching tool 74 is mounted in the holder 72 with the pointed tip 76 being engaged with the upper surface 10 of the sample 8. The lead screw 32 is then rotated, causing linear translational movement of the linear slide body 26 over the base plate 50. In this way, the sample surface 10 is translationally linearly moved relative to the pointed tip 76 of the tool 74, the translational position of the tip 76 being fixed (subject to rotation of the tip 76 as described below) relative to the base plate 48 by way of the support member 62 of the arm 58 and the bracket 52.

The pin member 86 which is mounted to the linear slide body 26 by the support wall 90 is accordingly translationally horizontally moved by rotation of the lead screw 32. This causes progressive rotation of the holder 72 and correspondingly the pointed tip 76 of the tool 74 about the pivot bearing 78. In this way, the angle of incidence between the scratching tool 74 and the sample surface 10 is progressively varied together with translational movement of the scratching tool 74 along the sample surface 10.

The first force transducer 92 senses any tangential force in a direction along the sample surface 10 which is applied to the sample 8 by the scratching tool 74. This is achieved by detecting the elastic movement of the platen 4 in a direction parallel to the tangential direction of movement of the scratching tool 74 over the sample surface 10. The variation of that tangential force together with the angle of incidence of the scratching tool 74 and/or with the translational distance of relative movement between the sample 8 and the scratching tool 74 can be correlated.

In addition, when the linear slide body 26 is traversed, the force applied through the helical tension spring 102 by way of the urging member 64 and the support member 62 to the holder 72 varies with translational movement of the scratching tool 74 along the sample 8. In the illustrated embodiment of Figure 1, as the sample 8 is traversed in the direction from right to left in the drawing, the force applied through the helical spring 102 is progressively increased as a result of progressive tensioning of the helical spring 102. The arm 58 is caused to rotate in an anti-clockwise direction by the spring 102. This causes an increased load to be applied to the arm 58 which in turn applies an increasing downwardly directed load on the holder 72 and hence on the scratching tool 74. The scratching tool 74 also rotates in an anti-clockwise direction as the sample 8 is traversed in the direction from right to left in the drawing, thereby gradually increasing the angle of incidence between the scratching tool 74 and the sample surface 10. The second force transducer 94 senses the force applied through the helical spring 102. The output of the second force transducer 94 can be correlated with the translational movement of the sample 8 and/or the

tangential force detected by the first force transducer 92 and/or the angle of incidence of the scratching tool 74.

CLAIMS:

1. A testing apparatus for evaluating the scratch resistance of a sample, the apparatus comprising a support for the sample to be tested, a holder for a scratching tool, a drive device for causing relative translational movement between the support and the holder and an inclination varying device for progressively varying an angle of incidence between the scratching tool and a sample surface during relative translational movement between the scratching tool and the sample surface.

2. Apparatus according to claim 1, wherein the inclination varying device comprises an arm extending above the support, a pivot bearing which is located on the arm and about which the holder is pivotally mounted and a rotatable connection between the holder and the support.

3. Apparatus according to claim 2 wherein the rotatable connection comprises a pin member mounted to a wall and a slot provided in the holder, the pin member being rotatably received in the slot.

4. Apparatus according to claim 3 wherein the wall and the support are mounted on a slide member.

5. Apparatus according to claim 4 wherein the support is mounted on the slide member by at least one flexure member which permits elastic movement of the support in a direction tangential to the direction of movement of the scratching tool over the sample surface.

6. Apparatus according to claim 5 wherein the or each flexure member is substantially C-shaped in cross section and includes upper and lower horizontal wall members connected by a vertical wall member, the upper wall member being affixed to a lower surface of the support.

7. Apparatus according to any one of claims 3 to 6 further comprising a first force transducer mounted between the wall and the support for measuring a load established therebetween.

8. Apparatus according to any one of claims 2 to 7 wherein the arm is L-shaped and comprises a generally horizontal support member having the pivot bearing at a free end thereof, a generally vertical urging member, and a junction between the support and urging members, and further comprising a bracket to which the junction is pivotally mounted.

9. An apparatus according to claim 8 further comprising a biasing device connected to the urging member whereby in use tension of the biasing device causes rotation of the L-shaped arm and a downwardly directed load to be applied to the scratching tool in the holder.

10. Apparatus according to claim 9 wherein the biasing device is further connected to the wall, whereby translational movement of the support causes progressive variation of the downwardly directed load.

11. Apparatus according to claim 10 further comprising a second force transducer between the biasing device and the wall for determining a downward load applied to the sample surface by the scratching tool.

12. A method for evaluating the scratch resistance of a sample, the method comprising supporting a sample to be tested on a support, disposing a scratching tool having a pointed end in a holder whereby the pointed end engages a surface of the sample to be tested, causing relative translational movement between the support and the holder whereby the pointed end is translated relative to the sample surface, and progressively varying an angle of incidence between the scratching tool and the sample surface during relative translational movement between the scratching tool and the sample surface.

13. A method according to claim 12 wherein the angle of incidence is varied by pivoting the holder about a pivot bearing located on an arm extending above the support and by rotating a connection between the holder and the support.

14. A method according to claim 13 wherein the support is mounted on a slide member by at least one flexure member which permits elastic movement of the support in a direction tangential to the direction of movement of the scratching tool over the sample surface.

15. A method according to any one of claims 12 to 14 further comprising measuring a tangential load applied to the sample surface by the scratching tool.

16. A method according to any one of claims 12 to 15 further comprising applying a downwardly directed load to the scratching tool in the holder.

17. A method according to claim 16 wherein the translational movement of the support causes progressive variation of the downwardly directed load.

18. A method according to claim 16 or claim 17 further comprising determining the downward load applied to the sample surface by the scratching tool.

19. A testing apparatus for evaluating the scratch resistance of a sample substantially as hereinbefore described with reference to Figure 1.

20. A method for evaluating the scratch resistance of a sample substantially as hereinbefore described with reference to Figure 1.

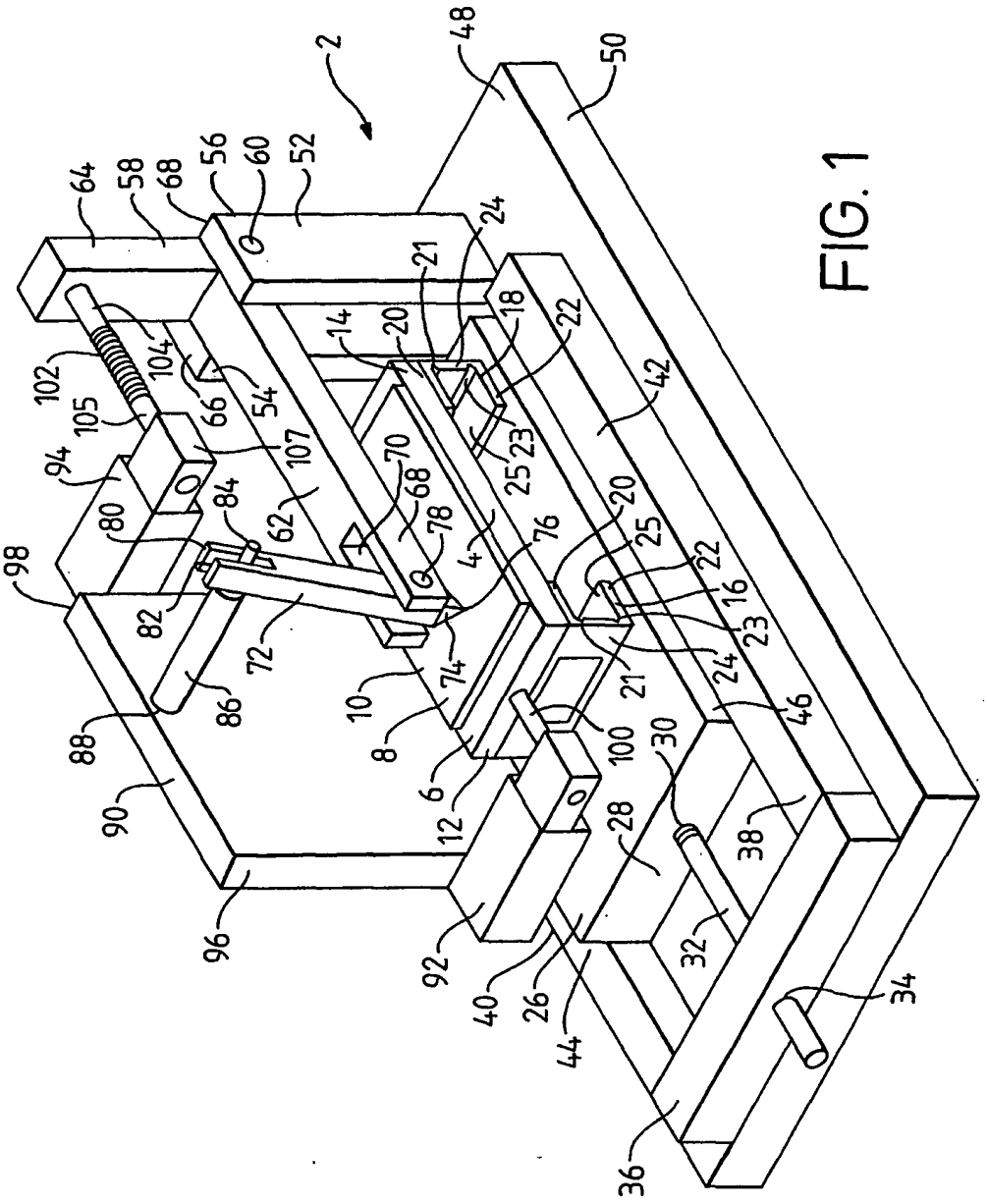

FIG. 1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/03823

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01N3/46 G01N19/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 785 198 A (HEETMAN J) 15 January 1974 (1974-01-15) column 2, line 9 - line 59; figure 1	1,2, 8-10,12, 13,16,17
X	PATENT ABSTRACTS OF JAPAN vol. 012, no. 114 (P-688), 12 April 1988 (1988-04-12) & JP 62 245131 A (NEC CORP), 26 October 1987 (1987-10-26) abstract	1,2,12, 13
X	DE 386 266 C (H BOROFSKI) 9 July 1922 (1922-07-09) page 1, line 45 - line 61; figures 1,2	1,2,12, 13
A	US 2 335 235 A (CLIFTON DONALD F) 30 November 1943 (1943-11-30)	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
18 December 2001	02/01/2002

Name and mailing address of the ISA	Authorized officer
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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Int[illegible]nal Application No
PCT/GB 01/03823

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